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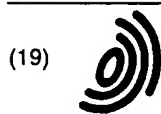
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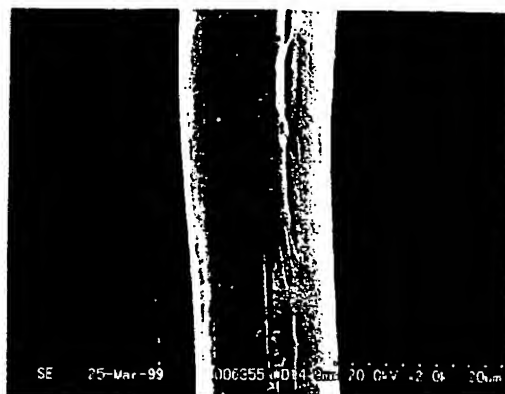
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(54) Divisible hollow copolyester fibers and divided copolyester fibers, woven or knitted fabric, artificial leather and nonwoven fabric comprising same

(57) Divisible hollow copolyester fibers having a satisfactory processing property, for example, carding property and capable of being divided by applying a mechanical stress thereto into fibril-like thin fibers, each include a hollow portion surrounded by a shell portion and extending along the longitudinal axes of the hollow fibers, wherein the shell portion is made from a copolyester of an acid component including terephthalic acid and 1

to 6 molar % of a sulfonate group-containing dicarboxylic acid, with a diol component including ethylene glycol; the hollow fibers have (1) thickness of 0.56 to 8.89 d tex (0.5 to 8.0 denier), (2) a hollow ratio of 25/100 or more, (3) a crystallization degree of 20% or more, and (4) a crystal size in (010) plane of 4 nm or more; and the shell portions each have a plurality of cracks intermittently extending along the longitudinal axes of the hollow fibers.

Fig.2



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to divisible hollow copolyester fibers capable of being easily divided into thin copolyester fibers by applying a mechanical stress to the hollow fibers; divided copolyester fibers made therefrom; and a woven or knitted fabric, an artificial leather and a nonwoven fabric each comprising the divided copolyester fibers.

[0002] More particularly, the present invention relates to divisible hollow copolyester fibers capable of being divided into thin copolyester fibers by applying a mechanical stress to the hollow fibers; and divided thin copolyester fibers made from the hollow copolyester fibers; and a woven or knitted fabric comprising the thin copolyester fibers and having a high heat-insulating property and a good hand, an artificial leather and a nonwoven fabric each comprising the thin copolyester fibers and having a soft hand.

2. Description of the Related Art

[0003] It is known that there is a strong demand for extremely fine fibers in industry and various attempts have been made for the processes for producing the extremely fine fibers and for the uses of the extremely fine fibers.

[0004] For example, a process for producing extremely fine fibers by melt-extruding a polymer through a spinneret having spinning holes with a small diameter, by taking up the extruded filamentary polymer melt streams at a high speed, to prepare undrawn filaments, and by drawing the undrawn filaments at a high draw ratio is known. This process is disadvantageous in that the thickness of the resultant individual fibers is limited to about 0.33 d tex (0.3 denier) or more, and thus the extremely fine fibers having a thickness less than 0.33 d tex (0.3 denier) are technically difficult to produce, and even when the production per se is possible, the productivity of the extremely fine fibers is very low and the production cost of the extremely fine fibers becomes very high.

[0005] In a process disclosed in Japanese Examined Patent Publication No. 42-19518, extremely fine fibers can be produced by spinning a mixture of two polymers insoluble in each other and by dissolving and removing one of the two polymers from the resultant mixed polymer fibers with a solvent. However, this process is disadvantageous in that the resultant segments formed from the two polymers insoluble in each other are easily separated at the interfaces therebetween from each other, and thus the resultant composite fibers exhibit a poor passing property through a carding machine, the resultant fibers have too low a thickness, the fiber length of the resultant fibers is too short and too random, and thus the resultant fibers cannot be used for certain purposes.

[0006] Also, Japanese Examined Patent Publication No. 47-30,723 and Japanese Unexamined Patent Publication No. 4-153,321 disclose a process for producing extremely fine fibers by preparing composite fibers in which two polymers insoluble in each other are arranged in an islands-in-sea form, or in a radiating form or in an alternate lamination form, and by dissolve-removing one polymer from the composite fibers. This process is useful for producing extremely fine fibers or filaments having a desired thickness and a desired fiber length. However, this process is disadvantageous in that since one of the two polymers must be removed from the composite fibers, the productivity of the extremely fine fibers is low and the production cost of the extremely fine fibers is high due to the complicated dissolve-removing procedure for the one polymer.

[0007] Further, Japanese Unexamined Patent Publication No. 62-133,164 discloses a process for producing extremely fine fibers by forming composite fibers in which two or more polymers are arranged in a radiating form or are alternately laminated, and by dividing the composite fibers by utilizing a difference in heat expansion between the two polymers, a difference in shrinkage between the two polymers, or by applying a mechanical force to the composite fibers. However, this process is disadvantageous in that the dividing property of the composite fibers is not sufficient high, a plurality of polymers must be used, the production apparatus is complicated and the productivity of the extremely fine fibers is low.

[0008] Still further, Japanese Unexamined Patent Publications No. 8-325,945 and No. 8-260,343 disclose a process for producing extremely fine fibers by forming hollow fibers from a polymer mixed with a certain additive, and applying a treatment, for example, alkali treatment for weight reduction of the hollow fibers, by which treatment, the polymer segments surrounding the hollow space and connected to each other are separated from each other. This process is disadvantageous in that there is a limitation to the design of the spinning nozzle for forming the hollow fibers from a plurality of polymer segments, and thus there is a limitation to the dividing number of the hollow fibers or to the thickness of the resultant divided fibers. Also, since the alkali treatment is necessary, there is a limitation on the use of the resultant divided fibers.

[0009] As mentioned above, the known processes for producing the extremely fine fibers by the conventional composite fiber dividing method or by the conventional one component polymer-removing method are unsatisfactory for

producing the extremely fine fibers useful in various fields with a high efficiency.

SUMMARY OF THE INVENTION

[0010] An object of the present invention is to provide divisible hollow copolyester fibers having a satisfactory processability, for example, in a carding procedure, for the production of textile products, and capable of being easily divided into a plurality of thin fibers by applying a mechanical stress to the hollow copolyester fibers, divided thin copolyester fibers produced from the hollow copolyester fibers, a woven or knitted fabric containing the divided thin copolyester fibers and having high heat-insulating property and a good hand, an artificial leather containing the divided thin copolyester fibers and having a soft hand, and a non-woven fabric comprising the divided thin copolyester fibers, having a soft touch and useful for paper-like sheet materials and packing materials.

[0011] The above-mentioned object can be attained by the divisible hollow copolyester fibers, the divided thin copolyester fibers, the woven and knitted fabric, the artificial leather and the nonwoven fabric of the present invention.

[0012] The divisible hollow copolyester fibers of the present invention each comprises (A) at least one hollow portion extending along the longitudinal axis of the hollow copolyester fiber and (B) a shell portion extending along the longitudinal axis of the hollow copolyester fiber, surrounding the hollow portion and comprising a copolyester of a dicarboxylic acid component comprising terephthalic acid and at least one sulfonate group-containing dicarboxylic acid in an amount of 1 to 6 molar % based on the total molar amount of the dicarboxylic acid component, with a diol component comprising ethylene glycol, which hollow copolyester fibers have (1) a thickness of 0.56 to 8.89 d tex (0.5 to 8.0 denier), (2) a ratio of a total cross-sectional area of the hollow portion to a total cross-sectional area of the individual fiber of 25/100 or more, (3) a degree of crystallization of the copolyester of 20% or more, and (4) a crystal size in (010) plane of the copolyester of 4.0 nm or more, and

the shell portions of which hollow copolyester fibers have a plurality of cracks located at random in the shell portions, and intermittently extending substantially along the longitudinal axes of the hollow copolyester fibers, and are thereby capable of being divided to form a plurality of thin fibers, upon applying a mechanical stress to the shell portions of the hollow copolyester fibers.

[0013] The divided thin copolyester fibers of the present invention are ones produced from the divisible hollow copolyester fibers as mentioned above, by applying a mechanical stress to the shell portions of the divisible hollow copolyester fibers.

[0014] The woven or knitted fabric of the present invention comprises the divided thin copolyester fibers as mentioned above, preferably in an amount of at least 20% by weight based on the total weight of all the fibers contained in the woven or knitted fabrics.

[0015] The artificial leather of the present invention comprises a substrate sheet containing the divided thin copolyester fibers as mentioned above, preferably in a content of at least 20% by weight, and a synthetic resin impregnated in the substrate sheet.

[0016] The non-woven fabric of the present invention comprises a plurality of fibers interlaced with each other or bonded to each other through a binder and comprising the divided thin copolyester fibers as mentioned above, preferably in a content of at least 30% by weight based on the total weight of the fibers contained in the nonwoven fabric.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

Figure 1 shows an electron microscopic view of a cross-sectional profile of an embodiment of the divisible hollow copolyester fibers of the present invention,

Fig. 2 shows an electron microscopic side view of an embodiment of the divisible hollow copolyester fibers of the present invention, and

Fig. 3 shows an electron microscopic side view of an embodiment of the divided copolyester fibers of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] The divisible hollow copolyester fibers of the present invention each comprise (A) at least one hollow portion extending along the longitudinal axis of the hollow copolyester fiber and (B) a shell portion extending along the longitudinal axis of the hollow copolyester fiber, and surrounding the hollow portion.

[0019] The shell portions of the divisible hollow copolyester fibers of the present invention comprise a copolyester of a dicarboxylic acid component comprising terephthalic acid and at least one sulfonate group-containing dicarboxylic acid in an amount of 1 to 6 molar %, based on the total molar amount of the dicarboxylic acid component, with a diol

component comprising ethylene glycol. Namely, the copolyester comprises, as principal recurring units, ethyleneterephthalate units and at least one type of ethylenesulfonic acid group-containing dicarboxylic acid ester units.

[0020] Also, the hollow copolyester fibers of the present invention have (1) a thickness of 0.56 to 8.89 d tex (0.5 to 8.0 denier), (2) a ratio of a total cross-sectional area of the hollow portion to a total cross-sectional area of the individual fiber of 25/100 or more, (3) a degree of crystallization of the copolyester of 20% or more, and (4) a crystal size in (010) plane of the copolyester of 4.0 nm or more.

[0021] Further, the shell portions of the hollow copolyester fibers of the present invention have a plurality of cracks located at random in the shell portion and intermittently extending substantially along the longitudinal axes of the hollow copolyester fibers, and are thereby capable of being divided into a plurality of thin fibers, upon applying a mechanical stress to the shell portions of the hollow copolyester fibers.

[0022] Referring to Fig. 1 showing an electron microscopic view of a cross section of a divisible hollow copolyester fiber of the present invention, a plurality of cracks are found in the cross section. The cracks penetrate from the outer surface of the shell portion to the inner surface of the hollow portion.

[0023] Referring to Fig. 2 showing an electron microscopic side view of a divisible hollow copolyester fiber of the present invention, a plurality of intermittent cracks or slits are found in the shell portion of the hollow fiber. The cracks or slits have a certain length and extend substantially along the longitudinal axis of the hollow fiber.

[0024] When a mechanical stress, for example, a beating force, is applied, the shell portion of a hollow copolyester fiber of the present invention is divided along the longitudinal axis of the hollow fibers into a plurality of thin copolyester fibers as shown in Fig. 3.

[0025] The divided thin copolyester fibers may be broken by the mechanical stress.

[0026] In the copolyester for the shell portions of the divisible hollow copolyester fibers of the present invention, the dicarboxylic acid component contains 1 to 6 molar %, preferably 2 to 5 molar % of at least one sulfonate group-containing dicarboxylic acid, in addition to terephthalic acid. If the content of the sulfonate group-containing dicarboxylic acid in the dicarboxylic acid component is less than 1 molar %, the resultant shell portions of the hollow copolyester fibers may be unsatisfactory in the formation of the cracks intermittently extending along the longitudinal axes of the hollow copolyester fibers. Thus, it may be difficult to divide the shell portions into a plurality of thin fibers, particularly extremely fine fibers. Also, when the content of the sulfonate group-containing dicarboxylic acid in the dicarboxylic acid component is more than 6 molar %, the stability of the melt-spinning procedure for the production of the divisible hollow copolyester fibers may be too low, while the cracks extending along the longitudinal axes of the hollow copolyester fibers can be formed in the shell portions.

[0027] The sulfonate group-containing dicarboxylic acid usable for the present invention includes sulfonate group-containing aromatic and aliphatic dicarboxylic acids and is preferably selected from 5-sodium sulfoisophthalic acid, 5-potassium sulfoisophthalic acid, 5-lithium sulfoisophthalic acid, 4-sodium sulfoisophthalic acid, 4-sodium sulfo-2,6-naphthalene dicarboxylic acid and ester-forming derivatives of the above-mentioned acids. These sulfonate group-containing dicarboxylic acids may be used alone or in a combination of two or more thereof.

[0028] In the copolyester usable for the present invention, the dicarboxylic acid component may contain at least one additional dicarboxylic acid, in addition to terephthalic acid and the sulfonate group-containing dicarboxylic acid, and the diol component may contain at least one additional diol, in addition to ethylene glycol, unless the attainment of the object of the present invention is obstructed.

[0029] The additional dicarboxylic acid is preferably selected from aromatic dicarboxylic acids, for example, isophthalic acid, diphenyldicarboxylic acid, and naphthalene dicarboxylic acid; aliphatic dicarboxylic acids, for example, succinic acid, adipic acid, and sebacic acid; and oxycarboxylic acids, for example, parahydroxybenzoic acid and 4-(β -hydroxyethoxy) benzoic acid. These additional dicarboxylic acids may be employed alone or in a combination of two or more thereof.

[0030] The additional diol is preferably selected from aliphatic diols, for example, 1,3-propane diol, 1,6-hexane diol and neopentylglycol; aromatic diols, for example, 1,4-bis(β -hydroxyethoxy) benzene; and polyalkylene glycols, for example, polyethylene glycol and polypropylene glycol.

[0031] These additional diols may be used alone or in a combination of two or more thereof.

[0032] Preferably, the additional dicarboxylic acid and the additional diol are used in a total amount of 10 molar % or less based on the total molar amount of the dicarboxylic acid component.

[0033] Generally, with respect to the polyester resin for fibers, the higher the degree of polymerization of the polyester, the lower the stability of the melt-spinning procedure of the polyester, and the greater the difficulty of producing thin fibers. Also, the lower the degree of polymerization of the polyester, the greater the difficulty of producing hollow fibers having a large hollow space. Accordingly, the copolyester usable for the present invention preferably has an intrinsic viscosity (η) of 0.35 to 0.70, more preferably 0.40 to 0.55, determined in orthochlorophenol at a temperature of 35°C.

[0034] The copolyester for the shell portions of the divisible hollow copolyester fibers of the present invention is optionally added with one or more additives.

[0035] The additives include function-imparting agents, for example, anti-bacterial agents, hydrophilicization agents,

anti-tick agents and deodorants; and inorganic particles, for example, titanium dioxide, zinc oxide, barium sulfate, zirconium oxide, aluminum oxide, magnesium oxide, calcium oxide and tourmaline. These additives are selected in consideration of the use purpose of the final product of the divisible hollow copolyester fibers. When the inorganic particles are used, preferably the inorganic particles have an average particle size of 1.0 μm or less, more preferably from 0.1 to 0.7 μm , and are contained in an amount of 1 to 10% by weight, more preferably 2 to 7%, in the shell portions of the hollow copolyester fibers.

[0036] The divisible hollow polyester fibers of the present invention have an individual fiber thickness of 0.56 to 8.89 d tex (0.5 to 8.0 denier), preferably 1.11 to 4.44 d tex (1.0 to 4.0 denier), more preferably 1.67 to 3.33 d tex (1.5 to 3.0 denier). When the individual fiber thickness is less than 0.56 d tex (0.5 denier), the divisible hollow copolyester fibers cannot be produced with a satisfactory stability of the melt-spinning procedure, and the resultant hollow copolyester fibers have an unsatisfactory hollow ratio which refers to a ratio in total area of the cross-section of the hollow portion to the cross-section of the hollow fiber. Also, when the individual fiber thickness is more than 8.89 d tex (8.0 denier), the resultant shell portions of the hollow copolyester fibers has too large a thickness and thus the cracks are not satisfactorily formed in the shell portions along the longitudinal axes of the hollow copolyester fiber, and the shell portions are not divided into satisfactorily thin fibers, even when a mechanical stress is applied to the shell portions, while the stability of the melt-spinning procedure is good.

[0037] The divisible hollow copolyester fibers of the present invention has a hollow ratio, which refers to a ratio of a total cross-sectional area of the hollow portion to a total cross-sectional area of the individual hollow fibers, of 25/100 or more, preferably 40/100 to 60/100. When the hollow ratio is less than 25/100, the resultant hollow copolyester fibers cannot be satisfactorily divided into thin fibers even when a mechanical stress is applied thereto. However, when the hollow ratio is too high, the resultant hollow fibers have too small a thickness of the shell portions, are easily broken during the melt-spinning procedure and processing procedures, and exhibit poor mechanical properties. Usually, the hollow ratio of the hollow copolyester fibers is preferably not more than 85/100.

[0038] In each of the divisible hollow copolyester fibers of the present invention, preferably a single hollow portion is formed in such a manner that the cross-sectional profile of the hollow portion is substantially concentric with the cross-sectional profile of the hollow fibers, and thus the shell portion has a substantially uniform thickness. When the cross-sectional profile of the hollow portion is eccentric with the cross-sectional profile of the hollow fiber the thickness of the shell portion is uneven. The higher the eccentricity, the higher the uniformity of the thickness of the shell portion. Therefore, the resultant shell portion is difficult to evenly divide into fine fibers, and thus the resultant divided thin fibers are difficult to form into a woven, knitted or nonwoven fabric or a substrate sheet for an artificial leather, having a soft touch.

[0039] In the divisible hollow copolyester fibers of the present invention, the shell portions surrounding the hollow portions preferably have an average thickness of 5 μm or less, more preferably 1.0 to 3.0 μm . The shell portions having an average thickness of 5 μm can be satisfactorily divided into thin fibers. However, when the thickness of the shell portions is too small, the production of the hollow fibers may be difficult, and the hollow fibers may be easily broken during processing thereof and/or may exhibit a poor resistance to wearing.

[0040] The divisible hollow copolyester fibers of the present invention have a degree of crystallization of the copolyester of 20% or more, preferably 22 to 33%, and a crystal size in (010) of the copolyester of 4.0 nm or more, preferably 5.0 to 8.5 nm, determined from the half value width of a (010) plane diffraction peak appearing in a wide angle X-ray diffraction photograph. When the copolyester has the crystallization degree of 20% or more and the crystal size in (010) plane of 4.0 nm or more, the resultant hollow copolyester fibers exhibit a satisfactory dividing property. When the crystallization degree is less than 20%, and/or the crystal size is less than 4.0 nm, the resultant hollow copolyester fibers exhibit an unsatisfactory dividing property and thus are difficult to divide into a plurality of thin fibers, particularly extremely fine fibers.

[0041] In the divisible hollow copolyester fibers of the present invention, the shell portions have a plurality of cracks located at random in the shell portions and intermittently extending substantially along the longitudinal axes of the hollow copolyester fibers. The cracks have a limited length in the longitudinal direction of each hollow copolyester fiber and may completely or incompletely penetrate through the shell portion. The cracks may be in the form of slits or long, narrow openings. The cracks may include latent cracks along which the shell portion can be easily slitted upon applying a mechanical stress thereto. When no cracks are formed, the shell portion cannot be easily divided into thin fibers even when mechanical stress is applied to the shell portion.

[0042] While the divisible hollow copolyester fibers of the present invention as mentioned have a good mechanical properties in the longitudinal direction thereof, the mechanical properties of the hollow fibers in the transverse direction thereof are poor. Therefore, preferably, when a mechanical stress is applied to the shell portions of the hollow fibers, 90% or more, and mainly along the cracks intermittently extending substantially in the longitudinal direction of the hollow fibers, of the hollow fibers are each divided into 4 or more thin fibers, more preferably into 5 to 20 thin fibers.

[0043] Accordingly, extremely fine fibers can be produced from the divisible hollow copolyester fibers of the present invention. Also, when a heat treatment is applied to the divisible hollow copolyester fibers under tension before the

mechanical stress application, the dividing property of the hollow fibers can be enhanced.

[0044] The divisible hollow copolyester fibers of the present invention may be in the form of staple fibers or continuous filaments which may be chosen in response to the purpose and use of the hollow fibers.

[0045] The divisible hollow copolyester fibers of the present invention can be produced, for example, by the particular melt-spinning procedure described below.

[0046] A melt of a copolyester is extruded through a hollow filament spinneret having a plurality of spinning holes for forming hollow filaments, and a heating gas having a temperature of 150 to 230°C, preferably 180 to 210°C is blown toward the extruded hollow filamentary copolyester melt streams in a heating zone located 0 to 50 mm below the spinneret. The blowing angle of the heating gas is 30 to 45 degrees downward from a direction at right angles to the travelling path of the extruded hollow filamentary copolyester melt streams. Namely, the blow of the heating gas is in an upward direction, whereas the travelling of the extruded hollow filamentary copolyester melt streams is in a downward direction. Therefore, the blow of the heating gas and the travelling of the hollow filamentary copolyester melt streams are effected in a countercurrent relationship.

[0047] The blow speed of the heating gas is 1.0 to 5.0 m/sec, preferably 2.0 to 3.0 m/sec.

[0048] After passing through the heating zone, the hollow filamentary copolyester melt streams pass through a buffer zone located below the heating zone and having a length of 50 to 150 mm and are then cooled and solidified in a cooling zone located below the buffer zone and having a length of 100 to 450 mm, preferably 150 to 350 mm. In the cooling zone, a cooling air having a temperature of 15 to 35°C, preferably 20 to 25°C was blown toward the hollow filamentary copolyester melt streams at a blow speed of 0.2 to 4.0 m/sec., preferably 1.5 to 3.5 m/sec. When the cooling procedure is carried out under other conditions than those mentioned above, the resultant hollow filaments may be unsatisfactory in certain properties.

[0049] The cool-solidified copolyester filaments are taken up under a draft of 150 or more, preferably 150 to 500, more preferably 200 to 400 at a take-up speed of 500 to 2000 m/min., preferably 1000 to 1800 m/min.

[0050] When the spinning draft is less than 150, the stability of the melt-spinning procedure may be unsatisfactory and the crystal size in (010) plane of the copolyester in the fine structure of the resultant fibers may be too small. Also, when the take-up speed is more than 2000 m/min, the hollow copolyester fibers all having a hollow ratio of 25/100 or more and a satisfactory crystallization degree and crystal size may not be obtained, while the crystal size of the copolyester in the fine structure of the resultant hollow fibers in (010) plane may be large enough.

[0051] Further, when the take-up speed is less than 500 m/min, the resultant hollow fibers may have an unsatisfactory crystal size in (010) plane. When the melt-spinning draft is too high, the resultant undrawn hollow copolyester filaments may exhibit a low drawability. Accordingly, the melt-drawing draft preferably does not exceed 500.

[0052] The taken-up, undrawn hollow filaments are drawn and optionally heat-treated to an extent established in response to the final use of the resultant hollow copolyester fibers. The drawing is carried out, for example, in hot water at a temperature of 50 to 70°C at a draw ratio of 2.0 to 5.0. When no heat treatment is applied, the resultant drawn hollow copolyester fibers exhibit a high thermal shrinkage. When a heat treatment under tension is applied by using heating rollers or heating plates, the resultant hollow copolyester fibers exhibit a reduced shrinkage. Further, when the undrawn hollow copolyester filaments are drawn and then heat-treated in hot water while overfeeding the filaments into the heat-treatment procedure, the resultant hollow copolyester fibers exhibit a self-expansion property. During the drawing procedure, the above-mentioned specific fine structure of the hollow fibers causes a plurality of cracks located at random in the shell portions and intermittently extending substantially along the longitudinal axes of the hollow fibers to be formed in the shell portions.

[0053] The intermittent cracks may completely or incompletely penetrate from the outer surfaces of the hollow fibers to the inner surfaces of the hollow portions through the shell portions.

[0054] The drawn hollow copolyester fibers of the present invention may have latent cracks which are not visible in the shell portions of the hollow fibers and contribute to causing the shell portions of the hollow copolyester fibers to be divided into thin fibers.

[0055] The above-mentioned melt-spinning method is merely representative and does not limit the method of producing the divisible hollow copolyester fibers of the present invention thereto. Namely, the divisible hollow copolyester fibers of the present invention may be produced by another method.

[0056] The divisible hollow copolyester fibers of the present invention are used alone or in a combination thereof with other fibers, for example, synthetic polymer fibers other than the hollow copolyester fibers of the present invention and natural fibers, for example, cotton fibers and wool fibers, and semi-synthetic fibers, for example, viscose rayon fibers. When the divisible hollow copolyester fibers are contained and divided into thin fibers, the resultant fiber products exhibit enhanced soft touch and bulkiness.

[0057] The woven or knitted fabric of the present invention comprises the divided thin copolyester fibers of the present invention. In this woven or knitted fabric, the divided thin copolyester fibers are preferably contained in an amount of at least 20% by weight, more preferably at least 30% by weight based on the total weight of the fibers contained in the woven or knitted fabric. When the woven or knitted fabric is formed from fiber yarns containing the divisible hollow

copolyester fibers in an amount of 20% by weight or more, the hollow copolyester fibers in the woven or knitted fabric are divided into thin fibers during weaving or knitting and processing procedure for the woven or knitted fabric.

[0058] The resultant divided thin fibers contribute to enhancing the heat-insulating property, bulkiness and/or soft touch of the woven or knitted fabric.

[0059] The artificial leather of the present invention comprises a substrate sheet containing the divided thin copolyester fibers of the present invention and a synthetic resin impregnated in the substrate sheet. The substrate sheet is in the form of a woven or knitted or nonwoven fabric. The divided thin copolyester fibers are preferably present in an amount of at least 20% by weight, more preferably 30% by weight or more, in the substrate sheet.

[0060] When a substrate sheet containing the divisible hollow copolyester fibers of the present invention is subjected to a process for producing an artificial leather, the hollow copolyester fibers are divided into thin copolyester fibers during the artificial leather-producing procedure. Thus, the resultant artificial leather of the present invention exhibits enhanced soft touch, light weight and flexibility.

[0061] The nonwoven fabric of the present invention comprises a plurality of fibers interlaced with each other or bonded to each other through a binder and comprising the divided thin copolyester fibers of the present invention. The content of the divided thin copolyester fibers in the nonwoven fabric is preferably at least 30% by weight, more preferably at least 40% by weight, still more preferably at least 50% by weight.

[0062] When a nonwoven fabric is formed by interlacing fibers containing the divisible hollow copolyester fibers with each other, during the interlacing procedure, the divisible hollow copolyester fibers are divided into thin copolyester fibers. The resultant nonwoven fabric exhibits enhanced soft touch, light weight, and heat insulating properties.

[0063] When the nonwoven fabric is produced by a paper machine, the divisible hollow copolyester fibers are cut into a fiber length of 3 to 30 mm, and the resultant cut hollow fibers are subjected to a mechanical pulping procedure using a beating machine, for example, a disk refiner, to divide the hollow fibers into thin fibril-formed fibers. The pulping (beating) procedure for the hollow fibers is carried out under conditions established in response to the type of the beating machine. The resultant divided fibril-formed thin fibers obtained from the divisible hollow copolyester fibers are suspended in water. The resultant thin fiber slurry is added with a sheet-forming binder, and then is supplied to a paper machine, for example, a long wire paper machine, a short wire paper machine or a cylinder paper machine, and the resultant wet-laid nonwoven fabric is heat-dried through a Yankee drier. The resultant wet-laid nonwoven fabric produced by the above-mentioned wet method exhibits uniform and soft touch which has not yet been obtained by conventional nonwoven fabrics. When the divided thin copolyester fiber slurry is unsatisfactory due to foaming or insufficient dispersion of the fibers, conventional additives, for example, a dispersing agent or thickening agent, are added to the fiber slurry.

[0064] The binder usable for the wet-laid nonwoven fabric of the present invention may be selected from conventional adhesive materials for the paper formation, for example, natural water-soluble polymers, for example, gelatin and sodium alginate; semi-synthetic water-soluble polymers, for example, phosphoric acid-modified starches, cyanoethylated starches, carboxymethyl cellulose and hydroxypropylmethylcellulose; synthetic water-soluble polymers, for example, polyvinyl alcohols, poly(sodium acrylate) and polyacrylamide; and other water-soluble polymeric materials, for example, polyethylene glycol and polyphosphates. These binder materials may be employed alone or in a mixture of two or more thereof. The binder for the wet-laid nonwoven fabric may be selected from latices of water-insoluble polymers, for example, homopolymers and copolymers of vinyl chloride, vinyl acetate, styrene, acrylonitrile acrylate esters, butadiene and ethylene. The latices may contain a plasticizer and/or stabilizer.

[0065] The binder for the wet-laid nonwoven fabric may be in the form of fibers. The binding fibers are preferably selected from polyvinyl alcohol fibers and polyethyleneoxide fibers which exhibit a binding activity under a wet heating condition after the paper-forming procedure. Alternatively, the bonding fibers are selected from hot melt fibers of heat-fusible adhesive homopolymers and copolymers, for example, polypropylene fibers, chlorosulfonated polyethylene fibers, and ethylene-vinyl acetate copolymer fibers which exhibit an adhesive property at a temperature of 80 to 170°C at which the wet-laid nonwoven fabric produced by the paper machine are dried, and side-by-side type and core-in-sheath type heat-adhesive composite fibers comprising a heat-fusible, adhesive polymer and another polymer having a melting point of 20°C above that of the heat-fusible, adhesive polymer.

[0066] In the nonwoven fabric of the present invention produced by the wet method, the divided fibril-formed thin copolyester fibers of the present invention are preferably contained in an amount of 30% by weight or more, based on the total weight of the wet-laid nonwoven fabric. Also, the paper-forming binder is preferably contained in an amount of 5 to 30% by weight, based on the total weight of the wet-laid nonwoven fabric. When the amount of the binder is less than 5% by weight, the resultant wet-laid nonwoven fabric may exhibit an unsatisfactory mechanical strength and may be difficult to handle. Also when the amount of the binder is more than 30% by weight, the individual fibril-formed fibers are bonded to each other at portions thereof at which the fibers intersect each other to too large an extent, and thus the resultant wet-laid nonwoven fabric may not exhibit an enhanced soft touch which is expected from the use of the fibril-formed fibers. The wet-laid nonwoven fabric of the present invention optionally contains, in addition to the divided fibril-formed copolyester fibers and the binder, additional fibers, for example, natural pulp fibers, synthetic pulp

fibers and polyethylene terephthalate fibers. The additional fibers can impart a specific function or property, for example, a high mechanical strength, a thermal stability, a moisture absorption or a hydrophilicity, to the nonwoven fabric.

[0067] The shell portions of the divisible hollow copolyester fibers of the present invention can be easily divided into a plurality of fibers thinner than the hollow fibers, even when these hollow copolyester fibers are used in combination with other fibers, for example, non-hollow or hollow synthetic fibers, such as polyester fibers, or natural fibers, for example, cotton or wool fibers. Therefore, the resultant fiber products can exhibit specific properties due to the divided thin copolyester fibers.

[0068] For example, when conventional extremely fine fibers are subjected to a carding machine, the fibers are difficult to smoothly pass through the carding machine. Namely, the carding property of the divided thin copolyester fibers is very low. When the hollow copolyester fibers of the present invention are subjected to a carding procedure, merely intermittent cracks are formed in the shell portions of the hollow-fibers along the longitudinal axes of the hollow fibers, and then the hollow fibers are converted into bundles of the divided thin copolyester fibers, without separating the thin fibers from each other. Namely, the divided thin copolyester fibers can behave as bundles, and thus can pass smoothly through the carding machine.

EXAMPLES

[0069] The present invention will be further explained by the following examples which are merely representative and are not intended to limit the scope of the present invention in any way.

[0070] In the examples, the following tests were applied.

(1) Intrinsic viscosity

The intrinsic viscosity of a polyester resin was determined by using orthochlorophenol as a solvent at a temperature of 35°C

(2) Thickness of fibers

Thickness of fibers was measured in accordance with Japanese Industrial Standard (JIS) L 1015, 7-5-1A method.

(3) Hollow ratio

By using an image-analyzing system (trademark: PIAS-2, made by PIAS K.K.), a cross-sectional profile of an individual hollow fiber was enlarged at a magnification of 500, and the total cross-sectional area of the fiber and the cross-sectional area of the hollow portion of the fiber were measured.

The hollow ratio refers to a cross-sectional area ratio of the hollow portion and the fiber.

(4) Intermittent cracks

An enlarged microscopic photograph of a side surface of a hollow fiber was prepared, and the photograph was observed to check whether intermittent cracks or slits were formed on the peripheral surface of the hollow fiber along the longitudinal axes of the hollow fiber.

(5) Thickness of shell portion

In the enlarged cross-sectional profile of the hollow fiber at a magnification of 500, the total cross sectional area of the hollow fiber and the cross-sectional area of the hollow portion were measured, and the thickness of the shell portion was calculated from the total cross-sectional area of the hollow fiber and the cross-sectional area of the hollow portion. The test was applied to 20 hollow fibers and the thickness of the shell portion was represented by an average value of the 20 test results.

(6) Proportion in amount of hollow fibers each divisible into at least four thin fibers to all the hollow fibers.

An electron microscopic photograph of a large number of cross-sectional profiles of hollow copolyester fibers was prepared. With respect to 50 cross-sectional profiles selected at random from those in the photograph, the number of the cross-sectional profiles having 4 or more cracks capable of dividing the hollow fibers along the cracks was counted. Then the percentage of the divisible hollow copolyester fibers based on 50 hollow copolyester fibers was calculated.

(7) Average number of the divided thin fibers from the hollow copolyester fibers.

On the same photograph as used in the test (6), an average number of thin fibers which will be divided from an individual hollow copolyester fiber was calculated from the total number of thin fibers which will be divided from 10 individual hollow copolyester fibers selected from those appearing on the photograph.

(8) Degree of crystallization

A degree of crystallization of copolyester resin in hollow fiber was determined from a wide angle X-ray diffraction image of the fiber.

(9) Crystal size in (010) plane

A crystal size of copolyester crystals in (010) plane was determined from a half band width of a diffraction peak in a (010) plane in the wide angle X-ray diffraction image.

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(10) Melt-spinnability and drawability

(i) Spinnability of a copolyester resin into hollow fibers was evaluated as follows.

Class	Spinning result
3	The number of breakages of filaments was less than 0.1 per spinning orifice per day. The number of adhered filaments was less than 0.1 per spinning orifice per day.
2	The number of breakages of filament was 0.1 to 0.2 per spinning orifice per day. The number of adhered filaments was 0.1 to 0.2 per spinning orifice per day.
1	The number of breakages of filaments was more than 0.2 per spinning orifice per day. The number of adhered filaments was more than 0.2 per spinning orifice per day.

The term "adhered filament" used herein refers to two or more filaments fuse-adhered to each other to form a single filament.

(ii) A drawability of undrawn hollow filaments are evaluated on the following basis.

Class	Drawing result
3	The number of roll-windings of the filaments due to filament breakage was less than 1 per drawing roller per day. The number of undrawn filaments is less than 5 per 100,000 filaments.
2	The number of roll-windings of filaments due to filament breakage was 1 to 3 per drawing roll per day. The number of undrawn filaments was 5 to 10 per 100,000 filaments.
1	The number of roll-windings of the filaments due to filament breakage was more than 3 per drawing roll per day. The number of undrawn filaments was more than 10 per 100,000 filaments.

(11) Heat-insulating property

A specimen was subjected to a measurement of heat conductivity in accordance with JIS A 1412, and was evaluated in the four classes.

Class	Heat conductivity
A	0.048 kcal/m·h·°C or less
B	More than 0.048 but not more than 0.055 kcal/m·h·°C
C	More than 0.055 but not more than 0.060 kcal/m·h·°C
D	More than 0.060 kcal/m·h·°C

(12) Light weight property of fabric

A standard specimen was prepared from five pieces (area: 5 cm²) of a fabric prepared from hollow fibers having an individual fiber thickness of 1.67 d tex (1.5 denier) and a hollow ratio of 30%. The five pieces of the fabric was superposed. The thickness of each pieces of the standard fabric was measured and the volume and weight of the standard specimen was measured. The weight of the standard specimen per unit volume was calculated.

A specimen was prepared from a fabric having the same basis weight as that of the standard fabric, and the weight of the specimen per unit volume was calculated.

From the test results, the light weight property of the fabric was evaluated in the following 4 classes.

Class	Weight per unit volume
A	Significantly less than standard
B	Less than standard
C	Substantially equal to standard

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(continued)

Class	Weight per unit volume
D	Larger than standard

(13) Hand of woven, knitted or nonwoven fabric (softness, cool-feeling, draping property, cushioning property and compression resistance).

The hand of a woven, knitted or nonwoven fabric was evaluated by an organoleptic test and classified into A to D classes as follows

Class	Hand
A	Excellent
B	Good
C	Satisfactory
D	Bad

(14) Initial bulkiness of nonwoven fabric

An initial bulkiness of a nonwoven fabric was measured in terms of specific volume in accordance with JIS L 1097.

A web having dimensions of 20 cm × 20 cm and a weight (W) of 40g was prepared from a fiber mass by using a carding machine. The web was left to stand in the ambient atmosphere for one hour or more, then a thick plate having dimensions of 20 cm × 20 cm and a weight of 0.5 g/cm² was superposed on the web, a bullet (A) having a weight of 2 kg was placed on the thick plate for 30 seconds, the bullet (A) was removed from the thick plate, and the remaining web and thick plate were left to stand for 30 seconds.

The bullet-placing and removing procedures were repeated three times. After the bullet-removed web and thick plate were left to stand for 30 seconds, the heights in mm of the four corner bottoms the thick plate were measured and an height average (h₀) in mm of the measured heights was calculated. The specific volume (initial bulkiness) of the web is calculated in accordance with the following equation:

$$\text{Initial bulkiness (cm}^3/\text{g)} = (20 \times 20 \times h_0/10)/W$$

(15) Initial compressed bulkiness of nonwoven fabric

The initial compressed bulkiness of a nonwoven fabric was measured, in terms of specific volume, in accordance with JIS L 1097.

The same web as mentioned in the test (14) was superposed with a thick plate having dimensions of 20 cm × 20 cm and a weight of 0.5 g/cm², and then pressed with a bullet (B) having a weight of 4 kg for 30 seconds. Then the heights in mm of four corner bottoms of the thick plate were measured and an average (h₁) in mm of the measured height was calculated.

The specific volume (initial compressed bulkiness) of the web was calculated in accordance with the following equation:

$$\text{Initial compressed bulkiness (cm}^3/\text{g)} = (20 \times 20 \times h_1/10)/W$$

(16) Resistance to bending

A specimen having a width of 2.5 cm and a length of 9 cm was used. A lower end portion of the specimen was fixed in a length of 2 cm, and a bending force was applied to a portion of the specimen spaced 2 cm from the free end of the specimen. When the specimen was bent at an angle of 90 degrees, the resilience force created in the specimen was measured by a strain meter (digital force gauge). The bending resistance of the specimen was represented by a resilience force per cm of the width of the specimen.

(17) Card-passing property

A fiber mass in an amount of 2 kg was passed through a flat carding machine at a carding speed of 50 m/min. The carding property of the fiber mass was evaluated in the following 4 classed.

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Class	Card property
4	Card-passing property is excellent. No blocking of carding machine and no breakage of web occur and no neps are formed.
3	No card blocking and no web breakage occur. A small amount of neps are formed.
2	No card blocking occur. Small numbers of web breakages and nep-formations occur.
1	Card blockings, web breakages and nep formations are found.

(18) Spinnability

The processability of the hollow copolyester fibers in carding, combining, roving and fine spinning procedures was evaluated in the following 4 classes.

Class	Spinnability
4	No difficulty occurs in all of carding, combing, roving and fine spinning procedures.
3	No difficulty occurs in carding, combing and roving procedures.
2	No difficulty occurs in carding and combing procedures.
1	No difficulty occurs only in carding procedures.

(19) Bending strength (kg/cm²)

The bending strength of a specimen was calculated in accordance with the following equation.

$$\text{Bending strength (kg/cm}^2\text{)} = \frac{60 \times \text{Resistance to bending (g/cm)}}{[\text{Thickness (mm)}]^3}$$

(20) Buckling resistance

A specimen having dimensions of 20 cm x 20 cm was curved at a radius of curvature of about 5 mm, the curved portion of the specimen was held by fingers and the holding fingers are moved to shift the location of the curved portion, while the curving conditions of the specimen was observed by the naked eye. When the curved portion was kept in round form, the buckling resistance of the specimen was evaluated good and when the curved portion was sharply folded, the buckling resistance of the specimen was evaluated bad.

The buckling resistance was evaluated in 4 classes.

Class	Buckling resistance
4	Excellent
3	Good
2	Bad
1	Very bad

(21) Bending resilience

A specimen having a width of 2.5 cm and a length of 9 cm was bent around the transverse center line thereof to an extent such that the thickness of the bent specimen became three times the thickness of the specimen, and the repelling force generated in the bent specimen was measured by a strain meter. The bending resilience of the specimen was represented by a repelling force per cm of the width of the specimen.

The higher the bending resilience, the higher the applicability of the specimen to artificial leather.

(22) Flexing durability

The flexing durability of the specimen was determined in accordance with JIS K 6505,525.

(23) Breaking length

The breaking length of the specimen was determined by the testing method for tensile strength of paper and paperboard in accordance with JIS P 8113.

(24) Tear strength

The tear strength of the specimen was determined in accordance with JIS L 1096.

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Example 1

[0071] A polyethylene terephthalate copolyester resin containing 4.5 molar % of copolymerized 5-sodium sulfoisophthalic acid component (SIP), having an intrinsic viscosity of 0.45, and mixed with 0.07% by weight of titanium dioxide was melt-extruded through a melt spinneret having 2000 hollow filament-forming nozzles at a polymer temperature of 268°C at an extruding rate of 1600 g/min, the extruded hollow filamentary copolyester resin melt streams were cool-solidified and taken up at a take up speed of 1800 m/sec. The resultant undrawn hollow copolyester filaments had an individual filament thickness of 4.44 d tex (4.0 denier) and a hollow ratio of 50/100.

[0072] During the melt-spinning procedure, in a heating zone located 0 to 50 mm below the spinneret, hot air was blown at a temperature of 200°C at a blow speed of 3.5 m/sec. at an upward angle of 35 degrees from the direction at right angles to the travelling path of the hollow filamentary streams, toward the extruded hollow filamentary copolyester resin melt streams.

[0073] Then the hollow filamentary streams passed through the heating zone passed through a buffer zone having a length of 100 mm and located below the heating zone, and thereafter, in a cooling zone located below the buffer zone and having a length of 250 mm, cooling air was blown toward the hollow filamentary copolyester resin melt streams at a temperature of 25°C at a blow speed of 3.5 m/sec, to solidify the hollow filamentary copolyester resin melt streams into hollow copolyester filaments.

[0074] The resultant undrawn hollow copolyester filaments were drawn in a single stage in hot water at a temperature of 65°C at a draw ratio of 2.80; heat-treated under tension at a temperature of 140°C by using heating rollers; crimped by using a mechanical crimping machine, at a crimp number of 12 crimps/25 mm; heat-set with a hot air blow at a temperature of 120°C; and then cut into a length of 51 mm.

[0075] The resultant hollow copolyester staple fibers had an individual fiber thickness of 1.67 d tex (1.5 denier) and a hollow ratio of 50/100, and had a plurality of cracks intermittently extending substantially along the longitudinal axes of the fibers.

[0076] The test results are shown in Table 1.

Examples 2 and 3 and Comparative Example 1 to 5

[0077] In each of Examples 2 and 3 and Comparative Examples 1 to 5, undrawn hollow copolyester filaments were produced by the same procedures as in Example 1, except that the hot air blowing procedure and the cooling procedure were carried out under the conditions shown in Table 1.

[0078] The undrawn hollow copolyester filaments were drawn and heat treated under the conditions shown in Table 1 and then the drawn, heat-treated hollow copolyester filaments were crimped and cut in the manner as shown in Table 1.

[0079] The test results are shown in Table 1.

Table 1

Item	Example No.	Example					Comparative Example				
		1	2	3	1	2	3	4	5		
Melt-spinning conditions	Copolymerized SIP content (molar %)	4.5	1.5	4.5	7.0	0	4.5	4.5	4.5		
	Intrinsic viscosity dl/g	0.45	0.45	0.53	0.45	0.45	0.37	0.45	0.45		
	Hot air blow temperature (°C)	200	180	200	-	-	-	-	-		
	Hot air blow speed (m/sec.)	3.5	2.0	3.5	-	-	-	-	-		
	Heating zone length (mm)	50	50	50	-	-	-	-	-		
	Buffer zone length (mm)	100	100	100	-	-	-	-	-		
	Cooling air blow speed (m/sec.)	3.5	3.5	3.5	3.0	3.0	3.0	5.0	3.0		
	Cooling zone length (mm)	250	250	250	200	200	200	200	200		
Spinnability	Cooling air blow temperature (°C)	25	25	25	25	25	25	25	25		
	Undrawn filament thickness (d tex)	4.44	4.44	5.56	4.44	4.44	5.56	33.33	4.44		
Drawing conditions	Draw ratio	3	3	3	2	3	2	3	3		
	Heating roller temperature (°C)	2.8	2.8	3.5	2.8	2.8	3.5	3.0	2.8		
	Hot air heat-setting temperature (°C)	140	140	140	140	140	140	140	140		
Drawability	Hot air heat-setting temperature (°C)	120	120	120	120	120	120	110	50		
	Individual fiber thickness (d tex)	3	3	2	2	3	2	3	3		
	Hollow ratio (%)	1.67	1.67	1.67	1.67	1.67	1.67	11.11	1.67		
	Crystallization degree (%)	50	44	50	44	44	22	50	44		
	Crystal size (nm)	30	23	30	33	19	28	30	30		
	Intermittent cracks	8.5	7.8	8.5	8.7	3.7	5.8	7.8	3.2		
	Shell portion thickness (μm)	Formed	Formed	Formed	Formed	None	Formed	None	Formed		
	Average thin fiber number	2.45	2.63	2.45	2.63	2.60	4.0	6.70	2.45		
Properties of Hollow copoly-ester fibers	Average thickness of divided thin fibers (d tex)	15.1	5.8	15.0	3.80	0	2.5	0	2.1		
	% of divisible hollow fibers (%)	0.11	0.29	0.11	0.43	1.67	0.67	11.11	0.79		
		100	93	78	72	0	43	0	65		

Examples 4 to 7 and Comparative Examples 6 to 7

[0080] In each of Examples 4 to 7 and Comparative Examples 6 to 7, the hollow copolyester staple fibers (fiber length: 38 to 100 mm) having the properties shown in Table 2 were spun by a ring spinning process to produce spun yarns having a twist number of 17.1 turns/25 mm and a British cotton yarn count of 30. The spun yarns were woven to produce a plain weave fabric having a warp density of 87 yarns/25 mm, a weft density of 68 yarns/25 mm, and a width of 127 mm. The fabric was scoured and then dyed with a disperse dye.

[0081] In Example 7, the plain weave fabric was produced from the hollow copolyester staple fibers and cotton fibers in a weight ratio of 50:50.

[0082] The properties of the fabrics are shown in Table 2.

Table 2

Example No.		Example					Comparative Example	
Item		4	5	6	7		6	7
Type of fibers		PES	PES	PES	PES	Cotton	PES	PES
Properties of hollow copolyester fibers	Individual fiber thickness (d tex)	1.67	3.33	8.89	1.67	-	1.67	1.11
	Hollow ratio (%)	50	50	70	50	-	43	0
	Crystallization degree (%)	30	32	31	30	-	13	13
	Crystal size (nm)	8.5	8.4	8.7	8.5	-	3.0	3.0
	Intermittent cracks	Formed	Formed	Formed	Formed	-	None	None
	Shell portion thickness (μm)	2.45	3.59	4.22	2.45	-	2.45	-
	Average divided thin fiber number	15.1	18.3	22.3	15.1	-	1	1
	Divided thin fiber thickness (d tex)	0.11	0.18	0.39	0.11	-	1.67	1.11
	% of divided hollow fibers (%)	100	98	99	-	-	0	-
Mixing ratio in weight %		100	100	100	50	50	100	100
Spinnability of fibers		4	4	4	4		4	2
Properties of fabric	Heat insulating property	A	A	A	A		C	D
	Light weight property	A	A	A	A		B	D
	Soft touch	A	A	A	A		C	B
	Cool feeling	A	A	A	A		B	C

Examples 8 to 10 and Comparative Examples 8 and 9

[0083] In each of Examples 8 to 10 and Comparative Examples 8 and 9, high shrinkage hollow copolyester staple fibers (fiber length: 38 to 64 mm) and self expansion hollow copolyester staple fibers (fiber length: 38 to 64 mm) having the properties shown in Table 3 were mixed in the mixing weight ratio shown in Table 3. The hollow staple fiber mixture was subjected to a carding procedure to form a mixed hollow fiber web. The web was subjected to a needle-punching procedure using a needle loom (fiber locker loom) having punching needles each having one No. 40 regular barb, at a punching density of 800 punches/cm², to provide a nonwoven fabric having a basis weight of 157 g/m².

[0084] The nonwoven fabric was immersed in hot water at a temperature of 68°C for 2 minutes to allow the nonwoven fabric to shrink at an area shrinkage of 35%. The shrunk fabric was dewatered under vacuum and dried at a temperature of 50°C for 5 minutes. A dried nonwoven fabric having a basis weight of 242 g/m² was obtained. The nonwoven fabric was interposed between a heating metal drum and a 60 mesh stainless steel net belt at a temperature of 180°C for

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60 seconds, to obtain a nonwoven fabric having a thickness of 1.2 mm and a bulk density of 0.202 g/cm³.

[0085] An impregnation liquid (trademark: CRYSBON MP-185, made by DAINIPPON INKIKAGAKUKOGYO K.K.) comprising 100 parts by weight of a solution of 12% by weight of a polyurethane resin in dimethylformamide, mixed with 5 parts by weight of carbon black, was uniformly impregnated in the nonwoven fabric. Then, the impregnated nonwoven fabric was squeezed by a pair of squeeze rolls, then immersed in hot water at a temperature of 40°C to coagulate the impregnation liquid contained in the nonwoven fabric, washed with water to such an extent that substantially no solvent remained in the resin-impregnated nonwoven fabric, and finally dried. An artificial leather was obtained.

[0086] The test results are shown in Table 3.

Table 3

Item	Example No.		Example				Comparative Example			
			8		9		10		8	
Properties of hollow fibers	Individual fiber thickness (d tex)	1.67	50	1.67	3.33	70	3.33	50	1.67	1.67
	Hollow ratio (%)	23	30	30	29	31	30	13	18	13
	Crystallization degree (%)	6.5	8.5	8.7	4.5	8.5	8.5	3.5	3.7	3.5
	Crystal size (nm)	Formed	Formed	Formed	Formed	Formed	Formed	None	None	None
	Intermittent cracks	2.45	2.45	2.05	2.59	2.45	2.45	2.45	2.45	2.45
	Shell portion thickness (μm)	13.1	15.1	23.0	22.5	15.1	15.1	0	0	0
	Average thin fiber number	0.12	0.11	0.14	0.14	0.11	0.11	1.67	1.67	1.67
	Divided thin fiber thickness (d tex)	100	100	98	93	100	100	0	0	0
	% of divisible hollow fibers (%)	45	45	45	45	45	45	45	45	45
	Shrinkage at 70°C (%)	-10	-10	-10	-10	-10	-10	-10	-10	-10
Mixing weight ratio		60	40	60	40	20	80	60	40	60
Carding property		4	4	4	4	4	4	4	4	3
Properties of Artificial leather	Resistance to bending (g/cm)	1.7	60	1.7	61	82	2.4	2.8	2.8	2.7
	Bending strength (kg/cm ²)	68	68	68	68	52	52	47	47	94
	Bending resilience (g/cm)	4	4	4	4	2	2	1	1	49
	Buckling resistance	≥ 10 ⁵	≥ 10 ⁵	≥ 10 ⁵	≥ 10 ⁵	≥ 10 ⁵	≥ 10 ⁵	≥ 10 ⁵	≥ 10 ⁵	2
	Flexural durability (Times)	≥ 10 ⁵	≥ 10 ⁵	≥ 10 ⁵	≥ 10 ⁵	≥ 10 ⁵	≥ 10 ⁵	≥ 10 ⁵	≥ 10 ⁵	≥ 10 ⁵

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Example 11 to 15 and Comparative Examples 10 and 11

[0087] In each of Examples 11 to 15 and Comparative Examples 10 and 11, the hollow copolyester staple fibers (fiber length: 51 mm) having the properties shown in Table 4 were subjected to a carding procedure to form a web.

5 From the web, a nonwoven fabric having a basis weight of 60 g/m² was obtained.

[0088] The test results of the nonwoven fabric are shown in Fig. 4.

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Table 4

Item	Example No.	Example										Comparative Example	
		11	12	13	14	15	16	17	18	19	20	21	22
Properties of hollow fibers	Individual fiber thickness (d tex)	1.67	3.33	8.89	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.33
	Hollow ratio (%)	50	50	70	50	50	50	50	50	50	50	50	0
	Crystallization degree (%)	30	32	31	30	30	30	30	30	30	30	30	14
	Crystal size (nm)	8.5	8.4	8.7	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	3.1
	Intermittent cracks	Formed	Formed	Formed	Formed	Formed	Formed	Formed	Formed	Formed	Formed	Formed	None
	Shell portion thickness (μm)	2.45	3.59	4.22	2.45	2.45	2.45	2.45	2.45	2.45	2.45	2.45	-
	Average thin fiber number	15.1	18.3	22.3	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	0
	Divided thin fiber thickness (d tex)	0.11	0.18	0.39	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	1.33
	% of divisible hollow fibers (%)	100	100	100	100	100	100	100	100	100	100	100	0
	Mixing weight ratio (%)	100	100	100	50	50	50	50	50	50	50	100	100
Cordding property		4	4	4	4	4	4	4	4	4	4	4	2
Properties of Non-woven fabric	Initial volume (cm^3/g)	22	22	24	27	27	27	27	27	27	27	27	32
	Initial compression volume (cm^3/g)	17	18	19	21	21	21	21	21	21	21	21	22
	Draping property	A	A	A	B	B	B	B	B	B	B	B	B
	Heat insulation property	A	A	A	A	A	A	A	A	A	A	A	B
	Cushioning property	A	A	A	A	A	A	A	A	A	A	A	B
	Softness	A	A	A	A	A	A	A	A	A	A	A	B
	Cool-feeling	A	A	A	A	A	A	A	A	A	A	A	B

Examples 16 to 19 and Comparative Examples 12 and 13

[0089] The same noncrimped divisible hollow copolyester fibers having a thickness of 1.67 d tex (1.5 denier), a fiber length of 5 mm, a hollow ratio of 50%, a crystallization degree of 30%, a crystal size of 8.5 nm, and a plurality of intermittent cracks, as those in Example 1 were subjected to a fiber-dividing procedure using a disk refiner, in water in a liquor ratio (which refers to a ratio in weight of the fibers to water) of 1/100, to provide an aqueous slurry of the divided fibril-like fibers.

[0090] The aqueous divided fibril-like fiber slurry was added with (1) binder fibers having a heat-adhering temperature of about 120°C and consisting of side-by-side type composite fibers comprising a terephthalic acid/isophthalic acid/ethyleneglycol/diethyleneglycol copolyester side portion and a polybutylene terephthalate side portion, and having a thickness of 1.67 d tex (1.5 denier)-, a fiber length of 5 mm and a crimp number of zero; and (2) additional fibers consisting of non-hollow polyester fibers having a thickness of 0.56 d tex (0.5 denier), a fiber length of 5 mm and a crimp number of zero.

[0091] The binder fiber (1) and the additional fibers (2) were respectively employed in the amounts shown in Table 5.

[0092] The resultant aqueous mixed fiber slurry was subjected to a hand paper-forming procedure; the resultant wet-laid nonwoven fabric sheet was dried through a Yankee dryer; and the dried sheet was subjected to heat-bonding procedure at a temperature of 120°C. A wet-laid nonwoven fabric having a basis weight of about 50 g/m² was obtained. The test results are shown in Table 5.

Table 5

Example No.		Example				Comparative Example	
Item		16	17	18	19	12	13
Component fibers	Divided fibril-like fibers	80	50	30	95		20
	Additional polyester fibers	-	30	50		80	60
	Binder composite fibers	20	20	20	5	20	20
Properties of nonwoven fabric	Breaking length (km)	0.12	0.14	0.16	0.05	0.20	0.28
	Ultimate elongation (%)	4.1	5.5	6.8	10.7	6.1	7.8
	Tear strength (g)	34	36	42	13	52	45
	Soft touch	3	3	3	4	1	2

[0093] In the divisible hollow copolyester fibers of the present invention, the shell portions have cracks intermittently extending substantially along the longitudinal axes of the hollow fibers and can be easily divided along the cracks into a plurality of thin fibers, particularly extremely fine fibers. When the divided thin fibers are used for a woven or knitted fabric, the resultant fabric exhibits a high heat insulating property and a soft touch. Also, when the divided thin fibers are used for a substrate sheet of an artificial leather, the resultant artificial leather is advantageous in a high soft touch and an enhanced light weight property. When the divided thin copolyester fibers are used for a nonwoven fabric, the resultant nonwoven fabric exhibit enhanced light weight property, heat insulating property and soft touch. Especially, when a paper-forming procedure is applied to the divided thin copolyester fibers, the resultant wet-laid nonwoven fabric is advantageous in a good surface property even when the nonwoven fabric has a relatively low basis weight.

Claims

1. Divisible hollow copolyester fibers each comprising (A) at least one hollow portion extending along the longitudinal axis of the hollow copolyester fiber and (B) a shell portion extending along the longitudinal axis of the hollow copolyester fiber, surrounding the hollow portion and comprising a copolyester of a dicarboxylic acid component comprising terephthalic acid and at least one sulfonate group-containing dicarboxylic acid in an amount of 1 to 6 molar % based on the total molar amount of the dicarboxylic acid component, with a diol component comprising ethylene glycol,

which hollow copolyester fibers have (1) a thickness of 0.56 to 8.89 d tex (0.5 to 8.0 denier), (2) a ratio of a total cross-sectional area of the hollow portion to a total cross-sectional area of the individual fiber of 25/100 or more, (3) a degree of crystallization of the copolyester of 20% or more, and (4) a crystal size in (010) plane of the copolyester of 4.0 nm or more, and

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the shell portions of which hollow copolyester fibers have a plurality of cracks, located at random in the shell portions and intermittently extending substantially along the longitudinal axes of the hollow copolyester fibers, and are thereby capable of being divided into a plurality of thin fibers, upon applying a mechanical stress to the shell portions of the hollow copolyester fibers.

- 5 2. The divisible hollow copolyester fibers as claimed in claim 1, wherein in at least 90% of the hollow copolyester fibers, each of the shell portions is capable of being divided into at least four thin fibers, upon applying a mechanical stress to each of the shell portions of the hollow copolyester fibers.
- 10 3. The divisible hollow copolyester fibers as claimed in claim 1, wherein the shell portions have an average thickness of 5 μm or less.
- 15 4. Divided thin copolyester fibers produced from the divisible hollow copolyester fibers as claimed in claim 1, by applying a mechanical stress to the shell portions of the divisible hollow copolyester fibers.
5. A woven or knitted fabric comprising the divided thin copolyester fibers as claimed in claim 4.
- 20 6. The woven or knitted fabric as claimed in claim 5, wherein the divided thin copolyester fibers are contained in an amount of at least 20% by weight based on the total weight of all the fibers contained in the woven or knitted fabrics.
7. An artificial leather comprising a substrate sheet containing the divided thin copolyester fibers as claimed in claim 4 and a synthetic resin impregnated in the substrate sheet.
- 25 8. The artificial leather as claimed in claim 7, wherein the divided thin copolyester fibers are present in a content of at least 20% by weight in the substrate sheet.
9. A non-woven fabric comprising a plurality of fibers interlaced with each other and comprising the divided thin copolyester fibers as claimed in claim 4.
- 30 10. The non-woven fabric as claimed in claim 9, wherein the divided thin copolyester fibers are present in a content of at least 30% by weight based on the total weight of the fibers contained in the nonwoven fabric.

Fig.1

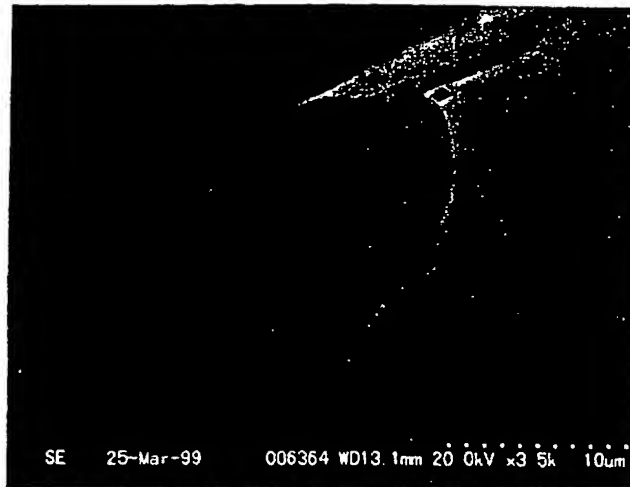


Fig.2

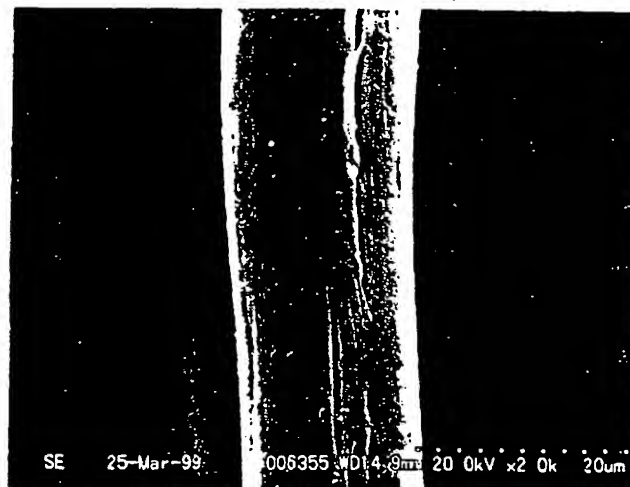
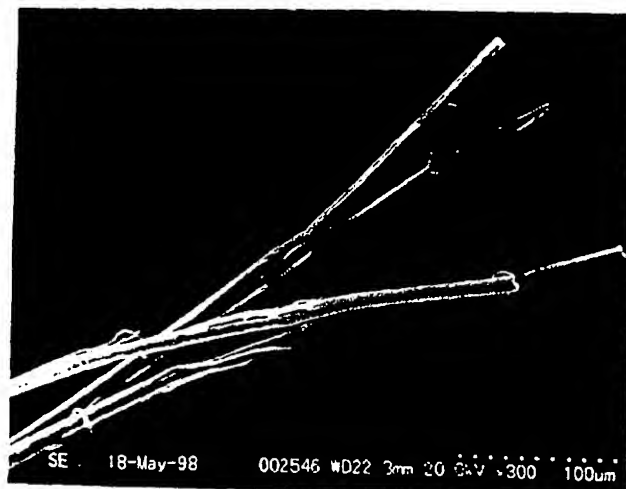


Fig.3



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EUROPEAN SEARCH REPORT

Application Number
EP 99 30 3358

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THE HAGUE		10 August 1999	Fiocco, M
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